(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 362 651 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
31.08.2011 Bulletin 2011/35

(51) Int Cl.:
H04N 7/24 *(2011.01)* ***H04L 29/06*** *(2006.01)*

(21) Application number: **10154153.0**

(22) Date of filing: **19.02.2010**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR
Designated Extension States:
AL BA RS

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(54) Multipath delivery for adaptive streaming

(57) The present invention relates generally to adaptive streaming and in particular to a method for delivering content via adaptive streaming technique over multiple communication paths and a device implementing the method.

Thus, the present invention concerns a method for providing a content to be rendered at a client device CD, said content being accessible to the client device CD via at least two independent first and second paths P1, P2, said content being available under at least two versions having an encoding quality corresponding to a supported bit rate BRA, BRB constraint, each of theses versions being temporally split into chunks corresponding to an identical duration of the content, a chunk being identified by a temporal index i and by one of the supported bit rate BRA, BRB.

According to the invention the method comprises the steps of:

S1 measuring by the client device CD a first available bit rate BR1 on the first path P1 and a second available bit rate BR2 on the second path P2;

S2 determining, by the client device CD, a requested bit rate RBR among the supported bit rate BRA, BRB from the measured first available bit rate BR1 and from the measured second available bit rate BR2;

S3 sending a first request via the first path P1, by the client device CD, for receiving a first part of the chunk identified by the index i and by the requested bit rate RBR and a second request via the second path P2 for receiving a second part of said chunk, said first and second part of the chunk being complementary;

S4 receiving by the client device CD the requested first part via the first path P1 and the requested second part via the second path P2.

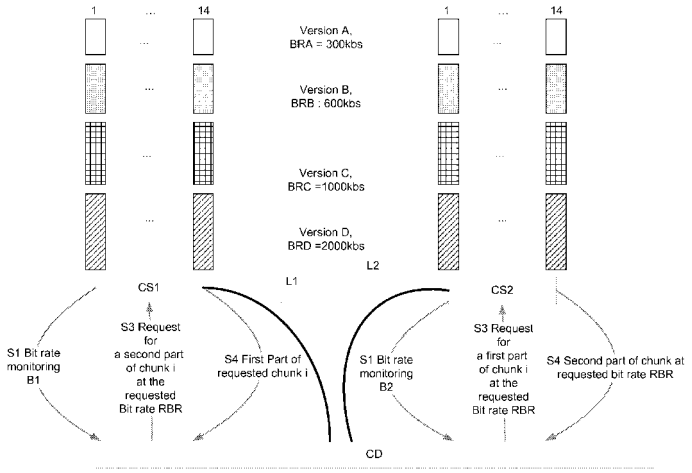

Figure 2

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Description

Field Of The Invention

[0001] The present invention relates generally to adaptive streaming and in particular to a method for delivering content via adaptive streaming technique over multiple communication paths and a device implementing the method.

Background Of The Invention

[0002] This section is intended to introduce the reader to various aspects of art, which may be related to various aspects of the present invention that are described and/or claimed below. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present invention. Accordingly, it should be understood that these statements are to be read in this light, and not as admissions of prior art.

[0003] Media delivery streaming solutions are mainly based on protocols such as Real time streaming Protocol (RTSP) as defined in the IETF RFC 2326, Microsoft Media Server (MMS) proprietary protocol from Microsoft or Real Time Messaging Protocol (RTMP) proprietary protocol from Adobe Systems.

[0004] More recently a streaming technique, said adaptive and based on HTTP protocol, has emerged with different flavors such as the "Move Adaptive Stream" from Move Networks, the "HTTP Live Streaming" from Apple Inc. and the "IIS (Internet Information Services) Smooth Streaming" from Microsoft. The benefit of using the HTTP protocol in these streaming solutions is its capability to cross over NAT and firewall seamlessly. The HTTP adaptive streaming technology provides a way to compensate erratic network behavior regarding available bandwidth by continuously and gracefully upgrading or downgrading the video quality in order to fit with the bandwidth constraint.

[0005] In more details, WO 2005/109224 A2 from Move Networks describes a mechanism in an Agent Controller Module hosted in the client side and able to adapt to the fluctuant network bandwidth thanks to the fact that the media to stream is previously organized in a plurality of streamlets, also called chunks, each of them being encoded from low to high bitrates. According to the available network bandwidth and some other additional information a monitoring tool incorporated in the Agent Controller Module uses the HTTP protocol to request the server to send the best suited chunk to be streamed over a TCP/IP connection. On an elementary chunk basis the quality is up-shifted or down-shifted according to the Agent Controller Module.

[0006] The IIS Smooth Streaming Technical Overview, from Alex Zambelli, Microsoft Corporation, March 2009, describes the IIS Smooth Streaming Technique based on HTTP protocol over TCP/IP connection. The media to be streamed by the Server is previously chopped into chunks representing for example one to ten seconds duration. Then these chunks are encoded according to the H.264/MPEG-4 AVC standard at different bitrates and stored within a MP4 file format container. The mechanism selecting the bit rate according to the network bandwidth fluctuation and requesting seamlessly the corresponding chunks to the server is entirely implemented in the client side through an application code, the Silverlight application. The HTTP Live Streaming supports dynamic switching between streams of different data rates in response to changing connection speeds.

[0007] Apple Inc. submitted an Internet Draft to IETF in October 2009 on an HTTP streaming method specification entitled "HTTP Live Streaming draft-pantos-http-live-streaming-02". The HTTP streaming architecture is based on 3 pillars: a Server, a Distribution, through a Web server or a Web caching system, and a Client. The media to be streamed is a video encoded in H.264 and an audio encoded in AAC. At a server, it is encapsulated in MPEG-TS containers and fragmented into chunks of equal duration with a specific tool named Apple stream segmenter. This tool generates the chunks that are saved into *.ts files and an index file *;m3u8 constituting the chunks playlist. Then a client fetches the index file first thanks to an URL pointer. The index file in turn specifies the location of the available media files, decryption keys, and any alternate streams available. For the selected stream, the client downloads each available media file in sequence.

[0008] HTTP adaptive streaming methods are generally oriented on adapting media viewing experience of the end user according to network congestion. Indeed, as soon as the network bandwidth measured by the client device decreases, the latter requests chunks which are less restrictive with respect to network bandwidth requirement; the "low bandwidth chunks". Conversely when the congestion problems decrease, the client device requests chunks which are more restrictive with respect to network bandwidth requirement; the "high bandwidth chunks".

[0009] The figure 1a illustrates the main steps of adaptive streaming method according to prior art. Figure 1a shows a video content has been (pre-) encoded into four versions (version A, version B, Version C and version D) with increasing supported bit rates implying progressive quality increase. The encoded video content is split into chunks that allow seamless switching from one bit rate to another. All the video chunks correspond to an identical fixed duration. These chunks are more or less big : thus requiring higher/lower bandwidth and providing better/lesser video quality, depending on the supported bit rates. All the versions of the content stored in the server CS1 (version A, version B, Version C and version D) are split into a fixed number of chunks, 14 chunks in the figure 1a.

[0010] On figure 1a, a first step of the method according to prior art is shown: a client device CD monitors the

bit rate BR1 of a path P1 connecting the client device CD to the server CS1.

[0011] In a second step, the client device CD determines a requested bit rate RBR compliant with the measured bit rate BR1. For example the requested bit rate RBR is the largest of supported bit rates BRA, BRB, BRC, BRD which is also less than or equal to the measured bit rate BR1.

[0012] In a third step, the client device requests via the path P1 a chunk identified by a temporal index i (here 1 < i <14) and the requested bit rate RBR.

[0013] In a fourth step, the client device CD receives still from the path P1 said chunk i at the requested bit rate RBR from the server CS1.

[0014] The four steps are repeated each time a chunk is needed.

[0015] The figure 1b shows a temporal evolution of the bit rate for a method of adaptive streaming of the prior art as presented above.

[0016] The curve on figure 1b shows the monitored bit rate BR1. Below the curve, one represents the chunk which is downloaded from the server. A typical adaptive client will continuously monitor the available bitrate (or bandwidth) and select the requested bit rate which is less than or equal to the available bit rate BR1 for the next chunks to be retrieved. Of course, depending on the implementation and the environment (network technology, application) the strategy may be conservative - i.e. the client requests higher bit rate chunk only after a certain time ensuring smooth upgrade transition; the client requests lower bit rate chunk as soon as it detects a bandwidth decrease implying rapid downgrade transition) - or more aggressive. In figure 1b, there are 4 different bit rates depicted corresponding to the four version of the encoded content.

[0017] With the adaptive streaming solutions explained above, the video stream that is acquired by the client CD chunk after chunk does not have a consistent quality with time. It is understood that the user experience may be damaged when the bandwidth goes down. The video never or rarely interrupts but the quality could be very poor. There is no other particular solution to preclude this situation than reducing the quality of transferred content. Increasing the receiver buffer will avoid the dry effect wherein a chunk delivery takes more time than expected but will not do anything against temporary low bandwidth availability.

[0018] One of the goals of the present invention is to fight the temporarily lack of bandwidth (or bit rate quick slowdown) by using at least two independent delivery paths both being controlled by the client. The at least two delivery paths must present transmission characteristics as much orthogonal as possible. This can be achieved having one client (e.g. a terminal) connected to a server via at least two different access networks (e.g. broadband xDSL and cellular 3G/LTE) or/and connected to a server connected to at least two similar access networks (possibly managed by two different internet service providers) or this can be realized by having one client connected to at least, two servers, each server being connected to a different access network. The latter may be easier to implement and we will focus on this implementation for the invention. In the rest of the document a server can be viewed as a physical box connected to a dedicated link/path or as a logical entity connected through a dedicated path/link as well.

[0019] It is understood that the invention applies with at least two links/paths/servers. In case of one machine hosting logical servers, the machine must support multi homing (i.e. can be connected to more than one network interface, each having a dedicated - e.g. IP - network address). Instead of having the chunk files stored on one server, they are stored on two servers accessible through two different communication paths (each server has its own network accesses and its own IP address). When the client detects that the available bit rate is slowing down on one of the paths, it can download the next chunk, or the next part of the chunk, from the alternative server. This can be implemented through a failover algorithm (use one main path and use the alternative path when the main path is struggling), through a load sharing algorithm (use both paths concurrently: a chunk is delivered partly from one of the server and partly from the other server or even through a bandwidth limited algorithm (guarantying a minimum global bit rate, by a main path P1 and additional paths P2, P3 in case an additional bit rate is needed to fulfill the global bit rate objective).

Summary Of The Invention

[0020] The technical problem that the present invention intends to solve is to improve an adaptive streaming method for render it less sensitive to problems of caused by temporary low bandwidth availability over a communication path.

[0021] Thus, the present invention concerns according to a first aspect, a method for providing a content to be rendered at a client device CD, said content being accessible to the client device CD via at least two independent first and second paths P1, P2, said content being available under at least two versions having an encoding quality corresponding to a supported bit rate BRA, BRB constraint, each of theses versions being temporally split into chunks corresponding to an identical duration of the content, a chunk being identified by a temporal index i and by one of the supported bit rate BRA, BRB.

[0022] According to the invention the method comprises the steps of:

S1 measuring by the client device CD a first available bit rate BR1 on the first path P1 and a second available bit rate BR2 on the second path P2;

S2 determining, by the client device CD, a requested bit rate RBR among the supported bit rate BRA, BRB from the measured first available bit rate BR1 and from the measured second available bit rate BR2;

S3 sending a first request via the first path P1, by the client device CD, for receiving a first part of the chunk identified by the index i and by the requested bit rate RBR and a second request via the second path P2 for receiving a second part of said chunk, said first and second part of the chunk being complementary;
S4 receiving by the client device CD the requested first part via the first path P1 and the requested second part via the second path P2.

[0023] Thus, the present invention concerns according to a second aspect, a client device CD for receiving a content to be rendered, said content being accessible to the client device CD via at least two independent first and second paths P1, P2, said content being available under at least two versions having an encoding quality corresponding to a supported bit rate BRA, BRB constraint, each of theses versions being temporally split into chunks corresponding to an identical duration of the content, a chunk being identified by a temporal index i and by the supported bit rate BRA, BRB.

[0024] According to the invention the client device CD comprises :

Means for measuring a first available bit rate BR1 on the first path P1 and a second available bit rate BR2 on the second path P2;
Means for determining a requested bit rate RBR among the supported bit rate BRA, BRB from the measured first available bit rate BR1 and the measured second available bit rate BR2;
Means for requesting via the first path P1 to receive a first part of a chunk identified by the index i and the requested bit rate RBR and via the second path P2 to receive a second part of said chunk, said first and second part of the chunk being complementary;
Means for receiving the requested first part of the chunk via the first path P1 and the requested second part of the chunk via the second path P2.

[0025] The invention proposes an enhancement of the adaptive streaming methods of the prior art based on the usage of more than one server either in switched way or in a concurrent way allowing:

- a better overall quality
- an improved service robustness from the client's perspective;
- improved service scalability from the server's perspective in case the chunks are encoded according to SVC.

[0026] Another advantage of the invention resides in its compatibility with architectures of known streaming devices. The method according to the invention can be implemented between a server and a client according to prior art without any modification for the player receiving the stream to be played back.

Brief Description Of The Drawings

[0027] The invention will be better understood and illustrated by means of the following embodiments and execution examples, in no way limitative, with reference to the appended figures on which:

Figure 1a, shows a client requesting a content to a server using an adaptive streaming method according the prior art, already described above;
Figure 1b, shows a temporal evolution of bit rate corresponding to an adaptive streaming method according the prior art, in regard with an evaluated bit rate, already described above;
Figure 2a, shows an implementation of a multi paths adaptive streaming method according to the embodiment;
Figure 2b is a block diagram of a client device according to the embodiment;
Figure 3a, shows a temporal evolution of measured available bit rate for an adaptive streaming method according to the embodiment thus using a concurrent approach,
Figure 3b, shows a temporal evolution of bit rate for an adaptive streaming method according the embodiment thus using a failover approach.

[0028] In figure 2b, the represented blocks are purely functional entities, which do not necessarily correspond to physically separate entities. Namely, they could be developed in the form of hardware or software, or be implemented in one or several integrated circuits.

Detailed Description Of Preferred Embodiments

[0029] It is to be understood that the figures and descriptions of the present invention have been simplified to illustrate elements that are relevant for a clear understanding of the present invention, while eliminating, for purposes of clarity, many other elements found in typical digital multimedia content delivery methods and systems. However, because such elements are well known in the art, a detailed discussion of such elements is not provided herein. The disclosure herein is directed to all such variations and modifications known to those skilled in the art.

[0030] A multi paths adaptive streaming method for delivering a content to a client device according the embodiment is described in this section and illustrated with figure 2.

[0031] The client device according to the embodiment is represented in figure 2. The client device CD is connected through two independent paths P1, P2. The client is also connected to a player 4 (not represented). On the server side, chunks are streamed upon the client request, using HTTP protocol over TCP/IP connection. The client

requests parts of chunks according to an algorithm described hereinafter and based on path bit rate measurements. A chunk should have been fully received by the client before it is decoded and rendered. The client device CD is able to request content stored simultaneously on two servers CS1, CS2.

[0032] Advantageously the servers CS1, CS2 are HTTP servers.

[0033] The content is for example a video or an audio content which is downloaded for being rendered at client side. For example once downloaded the client device CD transmits said content at a player (not represented on figure 2) chunk by chunk for being played back.

[0034] The content is for example generated by a content preparation tool. This tool generates compressed video and audio content (e.g. H264 and MP3 respectively) at at least two targeted (or supported) bit rate (e.g. BRA = 300 kbps, BRB = 600 kbps, BRC = 1000 kbps, BRD = 2000 kbps). The content preparation tool multiplexes them for producing a MPEG TS (Transport Stream) chunk serie per supported bit rate.

[0035] All the chunks correspond to an identical duration of the content e.g. 2 seconds for each targeted bit rate. A chunk is identified for example by a temporal index i (here $1 < i < 14$) and by one of the supported bit rate BRA, BRB, BRC, BRD.

[0036] On all the following figures, the chunks are represented as rectangle boxes : the horizontal size of said boxes are identical and correspond to the above described identical duration. The vertical size of said rectangle boxes illustrates the quality of said chunk and corresponds to one of said supported bit rate BRA, BRB, BRC, BRD. Then, all the chunks belonging to a chunk serie has an identical vertical size. But the size of the chunks belonging to a chunk serie does not have necessarily identical sizes. The sizes of the chunks of a serie identified by different temporal index depend on the temporal evolution of content.

[0037] The chunk series are stored on both servers CS1, CS2 as represented in figure 2 and identified by "version A", "version B", "version C" and "version D". In the chosen representation, all the chunks stored on both servers CS1, CS2 are identical except the index i.

[0038] The two servers CS1, CS2 are connected to the client device CD over two different access networks forming two independent paths (P1, P2).

[0039] At the connection set up, a manifest file is received by the client device CD from at least one of the servers CS1, CS2. This manifest file comprises a list of the supported bit rates BRA, BRB, BRC, BRD and for each supported bit rates BRA, BRB, BRC, BRD the list further comprises the total number of chunks, and the chunk size.

[0040] Advantageously a list of alternative servers is proposed in said manifest file.

[0041] The figure 3a shows the four main steps of a method for providing a content to client device CD according to the embodiment.

[0042] In a first step S1, the client device CD monitors the available bit rate on the paths P1, P2 : the available bit rate BR1 is measured continuously on the path P1 and the available bit rate BR2 is measured on the path P2.

[0043] Advantageously, the bit rates BR1, BR2 are measured periodically at a period corresponding to the chunk duration: here 2 seconds.

[0044] Advantageously, the step S1 of measuring first and second available bit rates BR1, BR2 consists in computing a round trip time of a request sent by the client device CD and of an acknowledgment message sent by the server CS1, CS2 in response to said request.

[0045] In a second step S2, the client device CD determines a requested bit rate RBR among the supported bit rate BRA, BRB, BRC, BRD from the measure of the bit rate BR1. The requested bit rate RBR is chosen exclusively among the supported bit rates BRA, BRB, BRC, BRD as defined in the manifest file. The requested bit rate RBR defines the bit rate of the requested chunk.

[0046] Advantageously, when the step S2 of determining the requested bit rate RBR is carried out for the first time, it comprises the step of receiving the supported bit rates BRA, BRB and for each supported bit rates BRA, BRB the size of the chunks, by the client device CD from at least one of the servers CS1, CS2.

[0047] Advantageously, the step S2 of determining the requested bit rate RBR consists in selecting the largest bit rate among the supported bit rates BRA, BRB which is lower than or equal to the sum SUM of the measured first available bit rate BR1 and of the measured second available bit rate BR2 minus a provision.

[0048] In a third step S3, the client device CD sends a request for a chunk identified by the temporal index i and the requested bit rate RBR to both servers CS1, CS2 via respectively paths P1 and P2. More particularly, the client device CD sends a request to the server CS1 via path P1 a first part of the chunk at the requested bit rate RBR and to the second server CS2 via path P2 a second part of the chunk, said first and second part of the chunk being complementary.

[0049] By using the term "complementary", one wishes to describe that there is no overlap between the first part and the second part and that the aggregation of both the first and second part result in the whole chunk.

[0050] Advantageously, the requested first part has a size proportional to a first ratio between the first bit rate BR1 and the requested bit rate RBR and the requested second part has a size proportional to a second ratio between the second bit rate BR2 and the requested bit rate RBR.

[0051] Advantageously, the requested first and second part have a size proportional to the size of the chunks received by the client device CD when the step S2 of determining the requested bit rate RBR is carried out for the first time.

[0052] The fourth step S4 consists in receiving by the client device CD concurrently the requested first part via the first path P1 and the requested second part via the

second path P2. The paths P1, P2 are used concurrently for providing the chunk.

[0053] By using the term "Concurrently" one wishes to highlight that both parallel paths P1, P2 are used simultaneously for downloading a single chunk in its entirety.

[0054] The client according to the embodiment is illustrated in figure 3b. The client comprises a first interface 14 to a first network which comprises the protocol stacks to communicate to the server CS1 located on the first network and a second interface 13 to a second network which comprises the protocol stacks to communicate to the server CS2 located on the second network. In particular the first and second network is the Internet. Of course it could be any other type of network and / enabling a client to communicate to a server.

[0055] The client also comprises a third interface 16 to connect to a player that is adapted to decode and render the content. Of course the third interface could enable connecting more than one player. It could be an interface to a network enabling to connect one or more players. The client also comprises a processor 11 for processing the applications stored in the client. It comprises storing means 12, such as a memory, for buffering the chunks or the parts of the chunks received from the servers before they are transmitted to the player. In particular the memory is a volatile memory. Of course the client comprises a non-volatile memory, not represented, for storing applications running on the client. The client could be implemented in a gateway device; the client device can be implemented as software or hardware.

[0056] Of course, various implementations of the method according to the embodiment are available involving the client device CD requesting parts of chunks via parallel paths P1, P2, ..., Pn. The client device CD opens connections to n servers CS1, CS2, ..., CSn where a content is available under at least two versions corresponding to respectively two different supported bit rates BR1, BRB. The client device CD sends requests for non-overlapping parts of a chunk of content concurrently from these servers CS1, CS2, ..., CSn.

[0057] A waited advantage of the method is to spread the traffic load across the available servers CS1, CS2, ... ,CSn. The load repartition is recomputed for every chunk. The load requested from each server is determined by the size of the chunk part requested from this server. The client device CD indicates the number of bytes it wishes to retrieve from each server by including a byte range header. This header has the following format:

Advantageously, the request sent by the client device is a HTTP request.

```
GET /path/example.jpg HTTP/1.1
Host: example.com
Range: bytes=0-999
```

[0058] In the above example, the request means that the client device requests for the first 1000 bytes of the specified resource "example.com". With each request/response with a server for a given range of a given chunk, the client device CD computes the current available bit rates BR1, BR2, ..BRn as follows:

$$BR1_i = \text{nbytes}_{SC1,i} \cdot 8 \div \text{time}_{SC1,i}$$

[0059] Where $\text{nbytes}_{CS1,i}$ is the number of bytes requested from server CS1 at for the chunk with temporal index i (also name "iteration "") and $\text{time}_{CS1,i}$ is the duration required to download the requested chunk part from server CS1 at iteration i.

[0060] This instantaneous available bit rate measurement can be used to feed a smoothing algorithm that guarantees both a progressive quality improvement and a quick response to severe network degradations. The smoothing algorithm gives an available bit rate estimate that can be used to request the next chunk.

$$E_{1,i} = f(BR1_i, BR1_{i-1}, ..., BR1_{i-k})$$

[0061] In case, n servers are available, the total available bit rate for downloading the next chunk is :

$$SUM = \sum_{s=1..n} E_{s,i}$$

[0062] Advantageously, the step S2 of determining the requested bit rate RBR comprises a step of evaluating a sum SUM of the measured first available bit rate BR1 and of the measured second available bit rate BR2 and the requested bit rate RBR is determined from said sum SUM.

[0063] Advantageously, it involves a further step S0 (not represented in figure 3a) carried out before step S1 for determining whether the first and second available bit rates BR1, BR2 measured over the paths P1, P2 are larger than a threshold BRTH1, and the four steps S1, S2, S3, S4 are carried out exclusively for paths P1, P2 over which the client device CD determined the measured available bit rate BR1, BR2 is larger than the threshold BRTH1.

[0064] In another embodiment, the concurrent mode of operation is performed just for reaching a target bit rate greater than or equal to a threshold BRTH2. A use case for this mode of operation would be to allow guarantying a given bit rate BRTH2 but not at any price by mobilising all the available paths. In other words, to use a second server CS2 only if it is needed for reaching the requested bit rate BRTH2.

[0065] The content is downloaded chunk by chunk to

the client device CD only from the single server CS1 via the path P1. The first available bit rate BR1 on the path P1 is measured by the client device CD. The four steps S1, S2, S3, S4 are carried out exclusively when the client CD determines that the available bit rate BR1 is less than a threshold BRTH2 and in that case the step S2 of determining the requested bit rate RBR consists in selecting the largest bit rate among the supported bit rates BRA, BRB which is lower than or equal to the threshold BRTH2 minus a provision.

[0066] The requested bit rate RBR of the next chunk to download is the largest supported bit rate (among the supported bitrates BRA, BRB, BRC, BRD as defined in the manifest file) lower than or equal to the total available bit rate BR1+BR2. The chunk size (expressed in bytes) can be approximated as:

$$\text{size} = RBR \cdot duration \div 8$$

[0067] With no minimum bit rate threshold, the number of bytes to download from the s-th server for the next iteration is directly proportional to the share of the s-th measure of available bit rate BR1 from the total bandwidth SUM.

$$\text{nbytes}_{s,i+1} = size \cdot \text{E}_{s,i} \div SUM$$

[0068] When a minimum bit rate threshold BRTH1 comes into play, one assigns a multiplicator ks to each server contribution, which allows to disable the servers whose bit rate is below the threshold. When the bit rate BRs corresponding to the path Ls between the client device CD and the server CSs is greater than or equal to the threshold then ks = 1. When the bit rate BRs is lower than the threshold then ks = 0. The total bit rate formula becomes:

$$\text{SUM} = \sum_{s=1..n} \text{k}_s \cdot \text{E}_{s,i}$$

which is obviously lower than the total bit rate calculated without threshold. The number of bytes to download from the s-th server becomes:

$$\text{nbytes}_{s,i+1} = size \cdot \text{k}_s \cdot \text{E}_{s,i} \div SUM$$

[0069] These numbers of bytes are used to request the appropriate byte ranges from each server, so if there are n servers, the client requests

Range [0; nbytes1-1] from the server CS1
Range [nbytes1; nbytes2-1 from the server CS2
Range [nbytes1 + nbytes2; nbytes3-1] from the server CS3

*Range $\left[\sum_{i=1..k-1} \text{nbytes}_i ;\right.$ nbytesk-1] from the server CSk (k<n)

Range $\left[\sum_{i=1..n-1} \text{nbytes}_i ;\right.$ endoffile] from the server CSn

[0070] The last range uses a special range end indication to cope with the fact that the chunks are often of unequal size. This way, the last range allows the client to retrieve the end of the chunk without knowing its exact size.

[0071] Upon reception of the byte ranges from all the servers, the client device CD simply concatenates the byte ranges in ascending order to reconstruct the entire chunk. This chunk is then consumed by the player module normally, as if it originated from a single server.

[0072] Advantageously, the four steps S1, S2, S3, S4 are carried out each time a chunk is downloaded from the servers CS1, CS2.

[0073] The method according to the embodiment is also adapted for overcoming drastic decrease of a bit rate over one of the paths.

[0074] Advantageously, the client device CD comprises means for determining whether the available bit rate over one of the paths (P1, P2, P3) is less than a threshold value (BRTH3).

[0075] The client device CD is adapted for example for determining whether a delivery duration of said requested part of the chunk i exceeds a threshold value DTH.

[0076] In consequence the client device CD may decide, during an iteration, to stop (or ignore) processing the end of an ongoing request (e.g. bytes range) and submit immediately a new request to a next server for getting the remaining bytes of the range to completed. This next server is for example the server which is reachable with highest bit rate or a group of server. In that case, the client sent a request for receiving the fragment of the part of the chunk which is not yet received.

[0077] Let's illustrate the method on an example where the content is accessible to the client device CD via three independent paths P1, P2, P3, for example these content are duplicated on three servers CS1, CS2, CS3, the requested bit rate RBR is determined form a first, a second and a third available bit rate BR1, BR2, BR3 measured respectively on the first, second and third paths P1, P2, P3. The client device CD has requested a first part of the chunk identified by index i and the requested bit rate RBR via the first path (P1), a second part of said chunk via the second path P3, a third part of said chunk via the third path (P3).

[0078] The method according to the embodiment involves further steps of:

[0079] (S5) determining by the client device (CD) whether the available bit rate over one of the paths (P1, P2, P3) is less than a threshold value (BRTH3);

[0080] When the requested first and second part requested by said client device (CD) are completely received and when the client device (CD) has determined that the available bit rate (BR3) over the path (P3) is less than the threshold value (BRTH3), a first fragment of the third part being received by the client device (CD), (S6) a second fragment of said third part, sending by the client device (CD), a request via the path (P1), for receiving a first part of the second fragment of the third part of the chunk i which is complementary to the first fragment of the third part of the chunk i via the path (P1) and for receiving a second part of the second fragment of the third part of the chunk index i via the path (P1), the first and second fragment being complementary parts of said third part.

[0081] For the path P2 having a bit rate below a threshold BRTH3 , the client requests a fragment of chunk (e.g. the current chunk). For example a fragment whose size is half the threshold BRTH3 multiplied by the chunk duration (e.g. 2s).

$$\text{nbytes}_{CS3,\,i+1} = \frac{(BRTH3 \div 8) \cdot \text{duration}}{2}$$

[0082] This fragment is only used to maintain an accurate bit rate evaluation for this particular path. The fragment is not passed to the player.

[0083] Advantageously, In order to limit the bit rate consumption it is possible to update the bit rate evaluation every n chunk reception, assuming that the bit rate (bandwidth) is constant between two measurements.

[0084] In a further embodiment, one adapts the algorithm to redistribute the load during the duration of a chunk.

[0085] The temporal evolution of the measured bit rate BR1, BR2 corresponding to the implementation without threshold BRTH is shown on figure 4a. A first curve (plain line) shows the evolution of measured bit rate BR1. A second curve (dashed line) shows the evolution of measured bit rate BR2. A third curve (dashed bold line) shows the evolution of measured total bit rate BR1+BR2. Here it is constant.

[0086] This is an advantage in comparison with prior art presented above: even if there are some temporal fluctuation of measured bit rate on a single path, the fluctuation are averaged when considering the aggregated bit rate here BR1 + BR2. Correlatively the requested bit rate BRB is constant and then, the quality of the chunks received by the client device is constant even there are bit rate fluctuations over the paths.

[0087] On the same figure one shows the first and second part of the chunk received by the client device CD.

[0088] The horizontal striped boxes show the first parts of chunk received via the first path P1 and the plain boxes show the second parts of chunk received via the second path P2. Here the received chunks have all the same requested bit rate RBR because the aggregated bit rate here BR1 + BR2 is constant. But, according to the relative fluctuation of measured bit rates BR1 and BR2 the relation between the size of the first part and the size of the second part varies temporally due to the temporal fluctuation of measured available bit rates..

[0089] A second temporal evolution of the measured bit rate and an illustration of the corresponding parts of chunks download from the server CS1, CS2 and corresponding to the implementation with a threshold BRTH2 is shown in figure 4b. The client requests and receives a chunk via a single path P1 when the measured available pit rate BR1 is below a greater than a threshold BRTH2. As soon as the measured bit rate BR1 is below said threshold, th client devices measure a second available bit rate BR2 and request parts of the chunk to both server CS1, CS2.

[0090] References disclosed in the description, the claims and the drawings may be provided independently or in any appropriate combination. Features may, where appropriate, be implemented in hardware, software, or a combination of the two.

[0091] Reference herein to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment can be included in at least one implementation of the invention. The appearances of the phrase "in one embodiment" in various places in the specification are not necessarily all referring to the same embodiment, nor are separate or alternative embodiments necessarily mutually exclusive of other embodiments.

Claims

1. A method for providing a content to be rendered at a client device (CD), said content being accessible to the client device (CD) via at least two independent first and second paths (P1, P2), said content being available under at least two versions having an encoding quality corresponding to a supported bit rate (BRA, BRB) constraint, each of theses versions being temporally split into chunks corresponding to an identical duration of the content, a chunk being identified by a temporal index i and by one of the supported bit rate (BRA, BRB), said method comprising the steps of:

   - (S1) measuring by the client device (CD) a first available bit rate (BR1) on the first path (P1) and a second available bit rate (BR2) on the second path (P2);
   - (S2) determining, by the client device (CD), a requested bit rate (RBR) among the supported bit rate (BRA, BRB) from the measured first

available bit rate (BR1) and from the measured second available bit rate (BR2);
- (S3) sending a first request via the first path (P1), by the client device (CD), for receiving a first part of the chunk identified by the index i and by the requested bit rate (RBR) and a second request via the second path (P2) for receiving a second part of said chunk, said first and second part of the chunk being complementary;
- (S4) receiving by the client device (CD) the requested first part via the first path (P1) and the requested second part via the second path (P2).

2. The method according to claims 1, said content being accessible to the client device (CD) via at least three independent paths (P1, P2, P3), the requested bit rate (RBR) being determined form a first, a second and a third available bit rate (BR1, BR2, BR3) measured respectively on the first, second and third paths (P1, P2, P3), the client device CD having requested a first part of the chunk identified by index i and the requested bit rate (RBR) via the first path (P1), a second part of said chunk via the second path (P3), a third part of said chunk via the third path (P3), **wherein** it involves further steps of:

(S5) determining by the client device (CD) whether the available bit rate over one of the paths (P1, P2, P3) is less than a threshold value (BRTH3);
- When the requested first and second part requested by said client device (CD) are completely received and when the client device (CD) has determined that the available bit rate (BR3) over the path (P3) is less than the threshold value (BRTH3), a first fragment of the third part being received by the client device (CD), (S6) a second fragment of said third part, sending by the client device (CD), a request via the path (P1), for receiving a first part of the second fragment of the third part of the chunk i which is complementary to the first fragment of the third part of the chunk i via the path (P1) and for receiving a second part of the second fragment of the third part of the chunk index i via the path (P1), the first and second fragment being complementary parts of said third part.

3. The method according to claims 1 or 2, **wherein** the step (S1) of measuring first and second available bit rates (BR1, BR2) consists in computing a round trip time of request sent by the client device (CD) and of a message sent in response to said request via said paths (P1, P2).

4. The method according to claims 1 to 3, **wherein** when the step (S2) of determining the requested bit rate (RBR) is carried out for the first time, it comprises the step of receiving the supported bit rates (BRA, BRB) and for each supported bit rates (BRA, BRB) the size of the chunks, by the client device (CD) via at least one of the paths (P1, P2).

5. The method according to claims 4, **wherein** the requested first part has a size proportional to a first ratio between the measured first available bit rate (BR1) and the requested bit rate (RBR) and the requested second part has a size proportional to a second ratio between the measured second available bit rate (BR2) and the requested bit rate (RBR).

6. The method according to claims 4 to 5, **wherein** the requested first and second part have a size proportional to said size of the chunks received by the client device (CD) when the step (S2) of determining the requested bit rate (RBR) is carried out for the first time.

7. The method according to claims 1 to 6, **wherein** the step (S2) of determining the requested bit rate (RBR) comprises a step of evaluating a sum (SUM) of the measured first available bit rate (BR1) and of the measured second available bit rate (BR2) and the requested bit rate (RBR) is determined from the sum (SUM).

8. The method according to claim 7, **wherein** the step (S2) of determining the requested bit rate (RBR) consists in selecting the largest bit rate among the supported bit rates (BRA, BRB) which is lower than or equal to the sum (SUM) of the measured first available bit rate (BR1) and of the measured second available bit rate (BR2) minus a provision.

9. The method according to claims 1 to 8, **wherein** the four steps (S1, S2, S3, S4) are carried out each time a chunk is completely received by the client device (CD).

10. The method according claims 1 to 6, **wherein** it involves a further step (S0 carried out before step (S1) for determining whether the first and second available bit rates (BR1, BR2) measured over the paths (P1, P2) are larger than a threshold (BRTH1), and the four steps (S1, S2, S3, S4) are carried out exclusively for paths (P1, P2) over which the client device (CD) determined the measured available bit rate (BR1, BR2) is larger than the threshold (BRTH1).

11. Client device (CD) for receiving a content to be rendered, said content being accessible to the client device (CD) via at least two independent first and second paths (P1, P2), said content being available under at least two versions having an encoding quality corresponding to a supported bit rate (BRA, BRB) constraint, each of theses versions being temporally

split into chunks corresponding to an identical duration of the content, a chunk being identified by a temporal index i and by the supported bit rate (BRA, BRB), **characterized in that** said client comprises :

- Means for measuring a first available bit rate (BR1) on the first path (P1) and a second available bit rate (BR2) on the second path (P2);
- Means for determining a requested bit rate (RBR) among the supported bit rate (BRA, BRB) from the measured first available bit rate (BR1) and the measured second available bit rate (BR2);
- Means for requesting via the first path (P1) to receive a first part of a chunk identified by the index i and the requested bit rate (RBR) and via the second path (P2) to receive a second part of said chunk, said first and second part of the chunk being complementary;
- Means for receiving the requested first part of the chunk via the first path (P1) and the requested second part of the chunk via the second path (P2).

12. Client device according to claim 11, **wherein** it further comprises means for receiving, via at least one of the first and second paths (P1, P2), information related to the supported bit rates (BRA, BRB) and for each supported bit rates (BRA, BRB) information related to the size of the chunks.

13. Client device according to claims 11 to 12, **wherein** the means for determining a requested bit rate (RBR) is adapted for evaluating a sum (SUM) of the measured first available bit rate (BR1) and of the measured second available bit rate (BR2) and said means is adapted for selecting the largest bit rate among the supported bit rates (BRA, BRB) which is lower than or equal to the sum (SUM) of the measured first available bit rate (BR1) and of the measured second available bit rate (BR2) minus a provision.

14. Client device according to claims 11 to 13, **wherein** it further comprises means for determining whether measured available bit rates (BR1, BR2) exceeds a threshold (BRTH1).

15. Client device according to claims 11 to 14, **wherein** it further comprises means for determining whether the available bit rate over one of the paths (P1, P2, P3) is less than a threshold value (BRTH3).

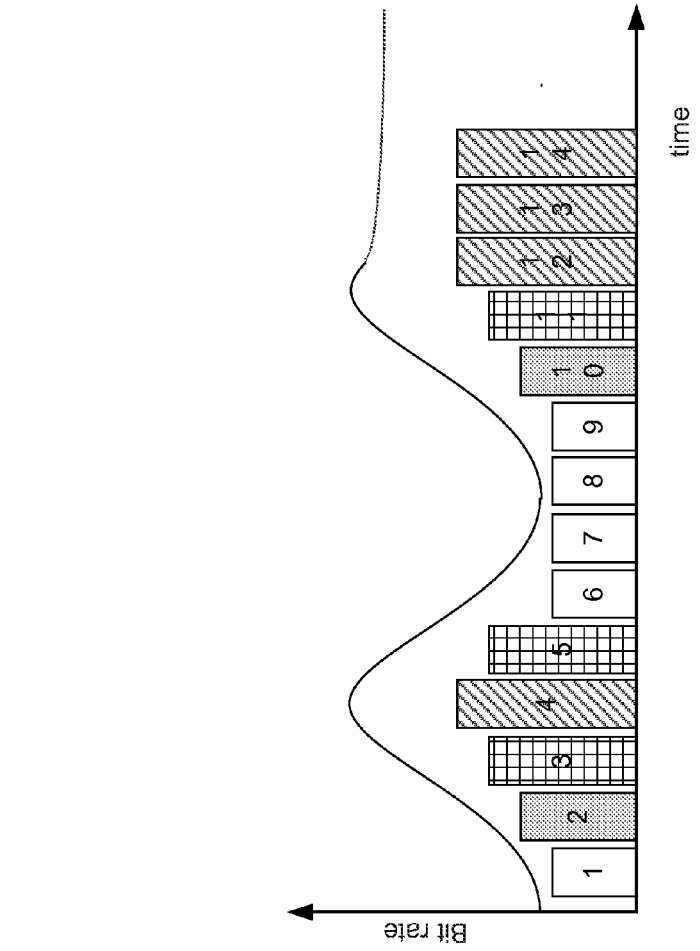

Figure 1b

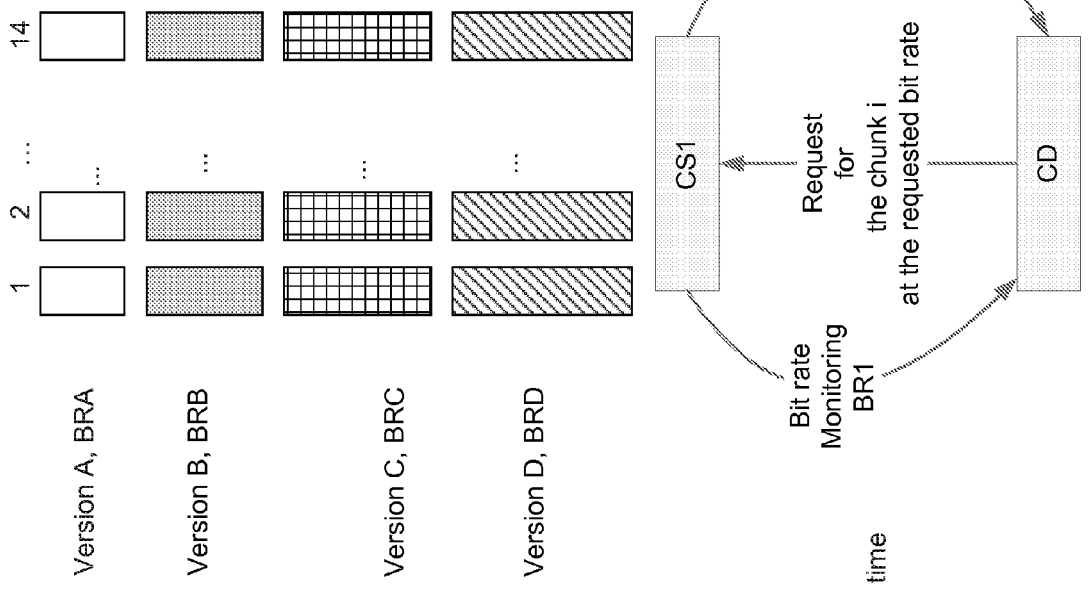

Figure 1a

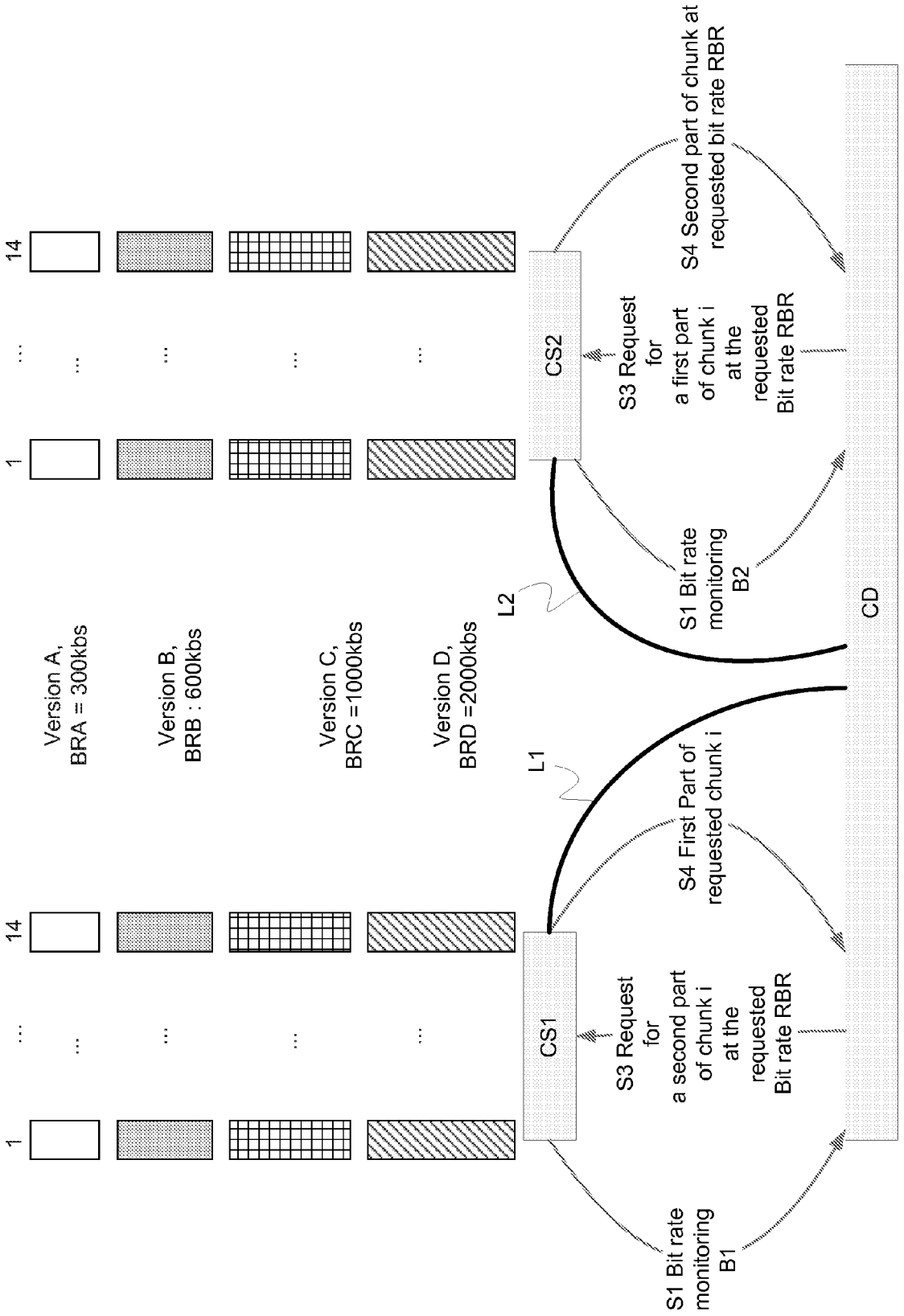
Version A,
BRA = 300kbs
Version B,
BRB : 600kbs
Version C,
BRC =1000kbs
Version D,
BRD =2000kbs
1
14
L1
L2
CS1
CS2
CD
S1 Bit rate monitoring B1
S3 Request for a second part of chunk i at the requested Bit rate RBR
S4 First Part of requested chunk i
S1 Bit rate monitoring B2
S3 Request for a first part of chunk i at the requested Bit rate RBR
S4 Second part of chunk at requested bit rate RBR

Figure 2

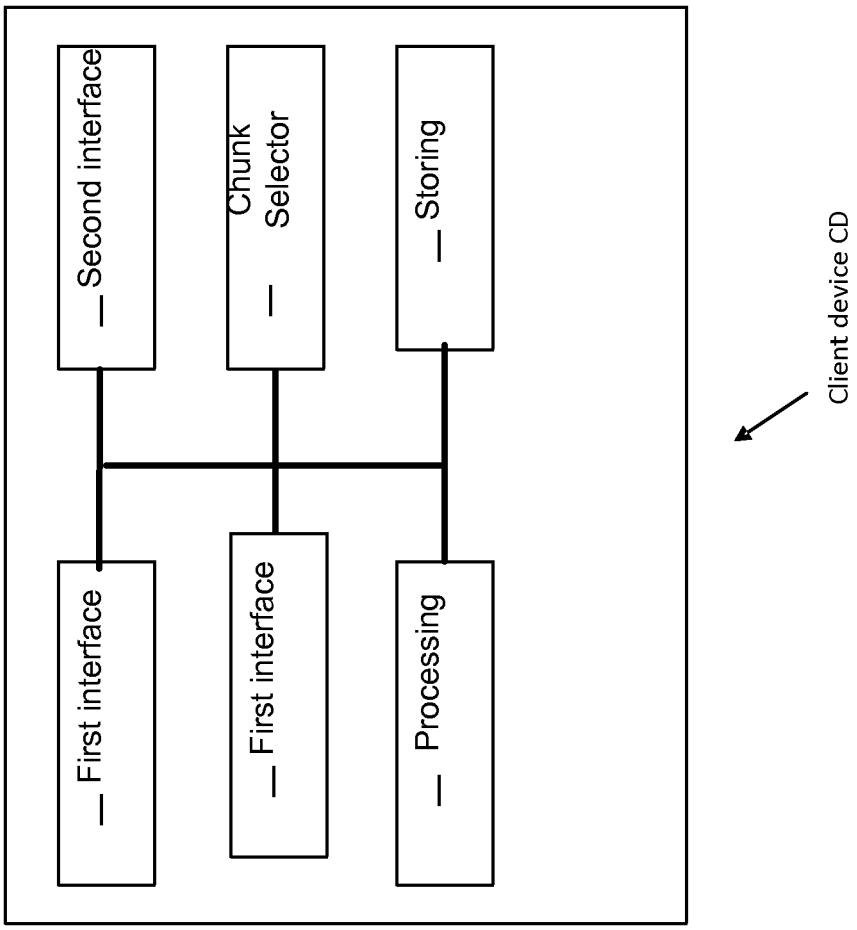

Figure 3b

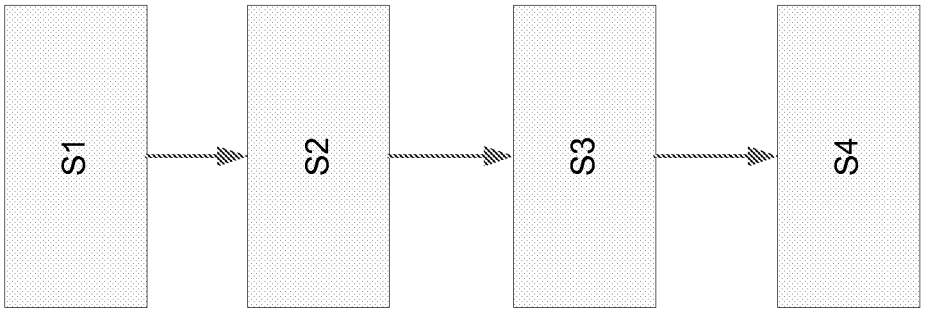

Figure 3a

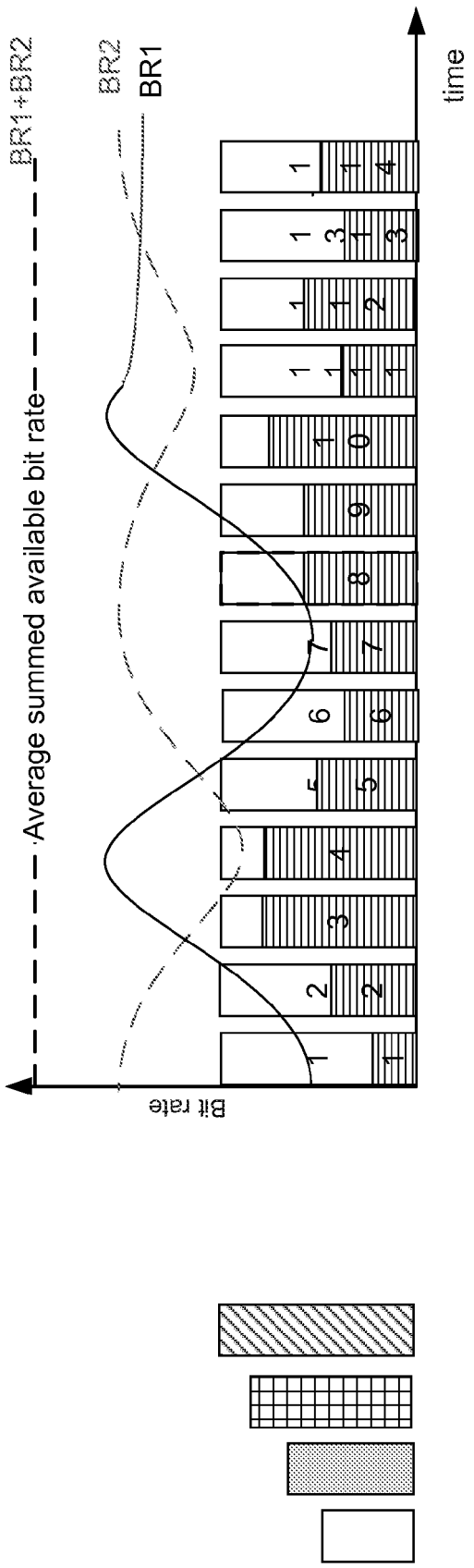

Figure 4a

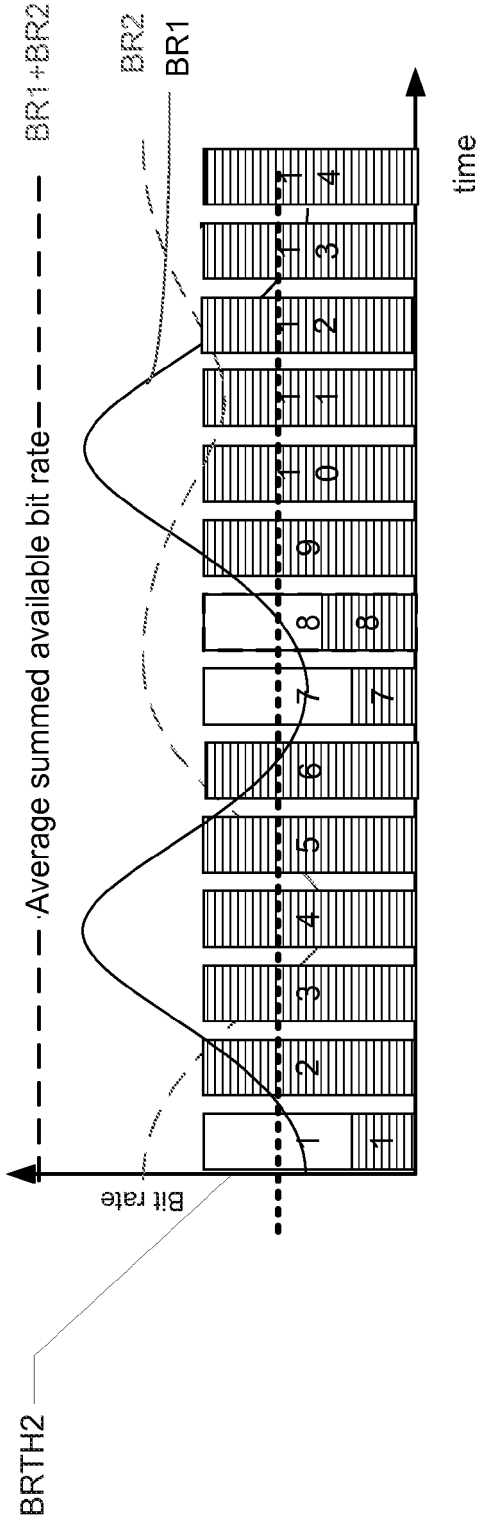

Figure 4b

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EUROPEAN SEARCH REPORT

Application Number
EP 10 15 4153

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	22 April 2010	Arpaci, Mutlu

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Y	US 2008/080473 A1 (THUBERT PASCAL [FR] ET AL) 3 April 2008 (2008-04-03) * paragraphs [0044], [0057], [0069] * * figures 1-10 *	10	
A	QUALCOMM EUROPE S A R L: "HTTP Streaming: Draft Specification for Static HTTP" 3GPP DRAFT; S4-090816_SPECIFICATION-HTTP, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, no. Sophia Antipolis, France; 20091109, 9 November 2009 (2009-11-09), XP050398951 [retrieved on 2009-11-06] * the whole document *	1-15	TECHNICAL FIELDS SEARCHED (IPC)

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A	US 2010/011117 A1 (HRISTODORESCU IONUT [US] ET AL) 14 January 2010 (2010-01-14) * abstract * -----	1-15	
A	BALDINI A ET AL: "Increasing performances of TCP data transfers through multiple parallel connections" COMPUTERS AND COMMUNICATIONS, 2009. ISCC 2009. IEEE SYMPOSIUM ON, IEEE, PISCATAWAY, NJ, USA, 5 July 2009 (2009-07-05), pages 630-636, XP031510536 ISBN: 978-1-4244-4672-8 * abstract * ----- -/--	1-15	TECHNICAL FIELDS SEARCHED (IPC)

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EP 10 15 4153

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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22-04-2010

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